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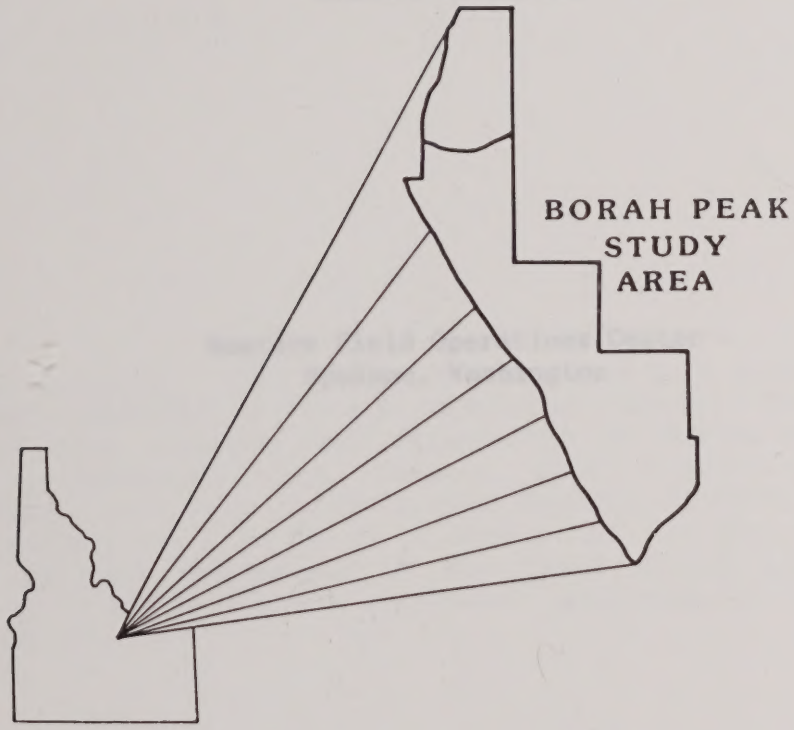
Mineral Resources of the Borah Peak Study Area, Custer County, Idaho



BUREAU OF MINES

UNITED STATES DEPARTMENT OF THE INTERIOR

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MINERAL RESOURCES OF THE BORAH PEAK STUDY AREA, CUSTER COUNTY, IDAHO

By
Michael S. Miller

Western Field Operations Center
Spokane, Washington

UNITED STATES DEPARTMENT OF THE INTERIOR
Manuel Lujan, Jr., Secretary

BUREAU OF MINES
T S Ary, Director

PREFACE

The Federal Land Policy and Management Act (Public Law 94-579, October 21, 1976) requires the U.S. Geological Survey and U.S. Bureau of Mines to conduct mineral surveys on U.S. Bureau of Land Management administered land designated as Wilderness Study Areas ". . . to determine the mineral values, if any, that may be present . . ." Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of a Bureau of Mines mineral survey of the Borah Peak Study Area, including the Borah Peak Wilderness Study Area, ID-047-004, Custer County, ID.

This open-file report will be summarized in a joint report published by the U.S. Geological Survey. The data were gathered and interpreted by Bureau of Mines personnel from Western Field Operations Center, East 360 Third Avenue, Spokane, WA 99202. The report has been edited by members of the Branch of Resource Evaluation at the field center and reviewed at the Division of Mineral Land Assessment, Washington, DC.

CONTENTS

	Page
Summary	4
Introduction	5
Setting	5
Previous studies	5
Present study	7
Acknowledgements	9
Geologic setting	9
Mining history	11
Mineral commodities and appraisal	11
Gold, silver, copper, lead, zinc, barium, and rare earth-related elements	17
Carbonates	17
Cement	18
Lime	18
Magnesium (Metal)	18
Sand and gravel	20
Silica	20
Geothermal energy	20
Oil and gas	23
Recommendations	23
References	24
Appendix	26

ILLUSTRATIONS

Figure 1.	Location of the Borah Peak study area, Custer County, ID	6
2.	Geologic map of the Borah Peak study area, Custer County, ID	12
3.	Mines, prospects, and mineral commodities in and near the Borah Peak study area, Custer County, ID	13

TABLES

Table 1.	Claims, prospects, and mineral commodities in and near the Borah Peak study area, Custer County, ID	14
2.	Selected dolostone sites in the Borah Peak study area, Custer County, ID	19
3.	Sand and gravel in alluvial fans in and near the Borah Peak study area, Custer County, ID	21
4.	Selected silica-rich quartzite sites in the Borah Peak study area, Custer County, ID	22

UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

ft^3	cubic foot
yd^3	cubic yard
°F.	degree Fahrenheit
ft	foot
in.	inch
mi	mile
'	minute
ppb	part per billion
ppm	part per million
%	percent
lb	pound
"	second
mi^2	square mile
oz	troy ounce
oz/yd^3	troy ounce per cubic yard

SUMMARY

In 1987 and 1988, at the request of the U.S. Bureau of Land Management, the U.S. Bureau of Mines studied the 3,100-acre Borah Peak Wilderness Study Area (ID-047-004) and a 788-acre parcel adjacent to the north in order to evaluate their identified mineral resources. The study area is located in Custer County, ID, about 18 mi northwest from MacKay.

The study area lies along the western foothills of the Lost River Range and is underlain by quartzite, sandstone, shale, argillite, dolostone, and limestone. The Lost River fault, a major active fault, lies along the length of the study area. Large alluvial fans spread out from valleys originating east of the study area.

There are at least five historical mining claims inside the study area boundaries; none are active. There are no oil and gas or geothermal energy leases or applications. No mineral commodities in the study area are currently minable.

Gold, silver, copper, lead, zinc, barium, and rare earth-related elements (thorium, uranium, beryllium, zirconium) in the study area are too small or too low-grade, by about 100 times, to be mined from the study area.

At least 10 million tons of carbonates, primarily dolostone, exist in the study area. These carbonates are low-grade and are unlikely to be mined for production of lime within the foreseeable future because of the presence of large deposits of similar or better grade material nearer markets. The dolostones are also considered an uneconomic, low-grade occurrence for magnesium metal. Limestones suitable for cement are low-grade and too small to mine and are also classified as occurrences.

At least 30 million yd^3 of sand and gravel exist in the study area, but are unlikely to be mined in the near future because large deposits of similar material lie nearer to markets outside and adjacent to the study area.

At least six million tons of silica-rich quartzite exist in the study area. The silica is unlikely to be mined within the foreseeable future because of lack of nearby markets.

No oil and gas resources were identified. The warmest spring flowed at 57° Fahrenheit and this and other springs will be uneconomic even for small-scale domestic heat-pump use within the foreseeable future because of low temperature, small flow, and lack of markets.

INTRODUCTION

This report describes the USBM (U.S. Bureau of Mines) portion of a cooperative study with the USGS (U.S. Geological Survey) to evaluate mineral resources and potential of the Borah Peak study area, including the Borah Peak WSA (Wilderness Study Area), Custer County, ID, at the request of the BLM (U.S. Bureau of Land Management). The USBM examines individual mines, prospects, claims, and mineralized areas, and evaluates identified mineral and energy resources. The USGS evaluates potential for undiscovered resources based on areal geological, geochemical, and geophysical surveys. Results of the investigations will be used to help determine the suitability of the Borah Peak study area for inclusion into the National Wilderness Preservation System. Although the immediate goal of this and other USBM mineral surveys is to provide data for the President, Congress, government agencies, and the public for land-use decisions, the long-term objective is to ensure that the nation has an adequate and dependable supply of minerals at a reasonable cost.

Setting

The 3,888-acre Borah Peak study area, which includes the 3,100-acre Borah Peak WSA (ID-047-004), is in Custer County, ID, about 18 mi northwest of Mackay, ID (fig. 1). The combined area is referred to as the study area.

The study area is in the western foothills of the Lost River Range, a north-northwest-trending block fault range typical of the basin-and-range physiographic province. The range is capped by Borah Peak, which, at 12,662 ft, is the highest point in Idaho. Access to the study area is by U.S. Highway 93 and by unpaved roads and vehicle trails. Elevations in the study area range from about 6,300 ft at the southern tip of the study area to about 9,360 ft north of Elkhorn Creek. At the nearby Mackay Ranger Station, normal temperatures are about 20° F. in January, about 70° F., in July, and average about 40° F annually. Precipitation at the Mackay Ranger station is normally about 1.3 in. in June, about 0.5 in. in November, and about 9 in. annually (National Oceanic and Atmospheric Administration, 1974). Sagebrush, grasses, conifers, and a few deciduous tree species comprise the vegetation, which is sparse in much of the study area.

Previous Studies

General discussions of geology pertinent to the Borah Peak study area are in Ross (1947, 1963), Nelson and Ross (1969), and Ruppel (1982). Economic geology of the region has been addressed by Umpleby (1917), Mapel (1956), and Capstick, Mayerle, and Buehler (1987). Geophysics, geochemistry, and remote sensing interpretations for the Borah Peak region are in Aero Service Division (1979), Ladelfe, 1980, and Wodzicki and Krason (1981).

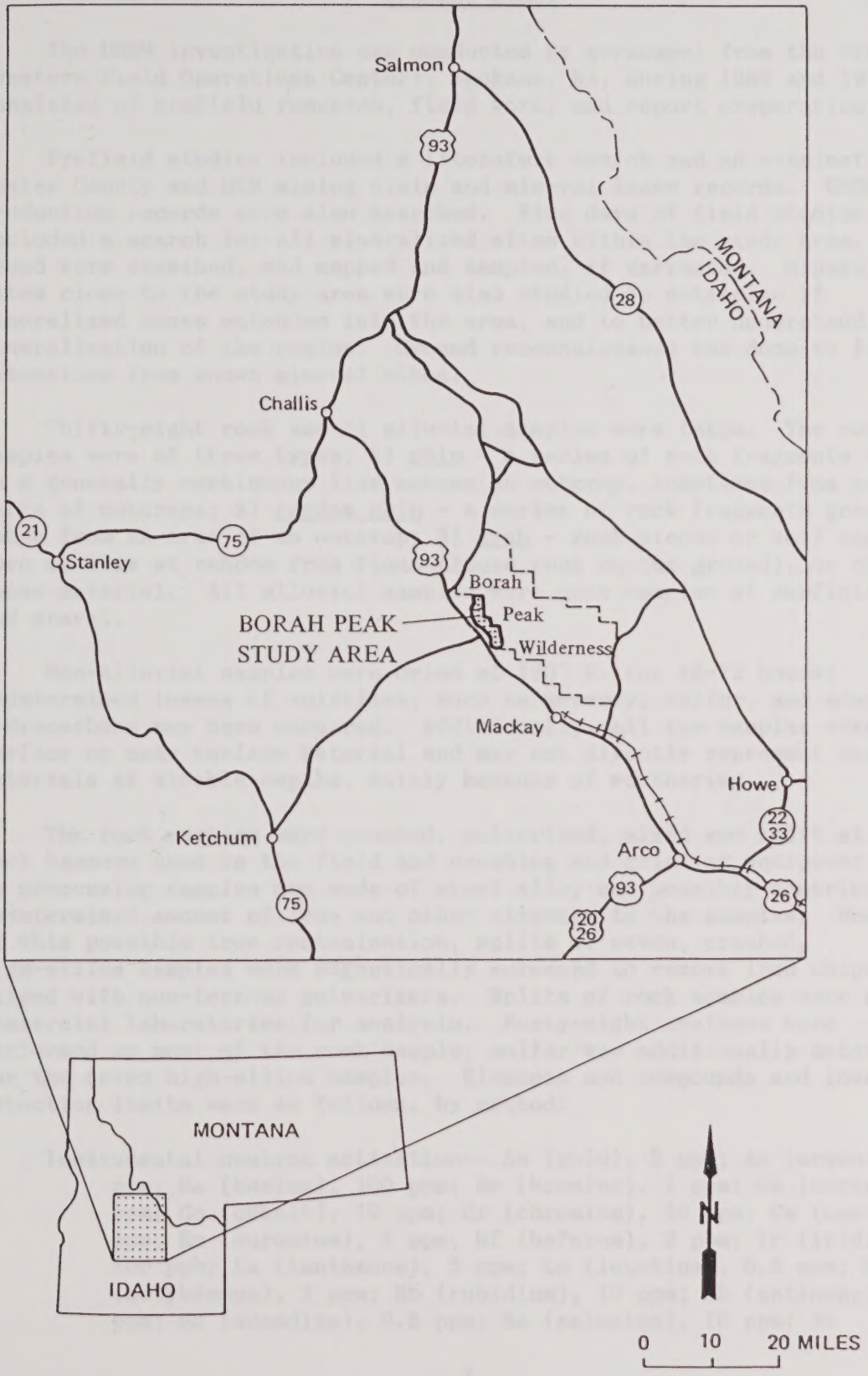

FIGURE 1.– Location of the Borah Peak study area, Custer County, ID (after Capstick, Mayerle, and Buehler, 1987)

Present Study

The USBM investigation was conducted by personnel from the WFOC (Western Field Operations Center), Spokane, WA, during 1988 and 1989 and consisted of prefield research, field work, and report preparation.

Prefield studies included a literature search and an examination of Custer County and BLM mining claim and mineral lease records. USBM production records were also searched. Five days of field studies included a search for all mineralized sites within the study area. Those found were examined, and mapped and sampled, if warranted. Mineralized sites close to the study area were also studied to determine if mineralized zones extended into the area, and to better understand mineralization of the region. Ground reconnaissance was done to find extensions from known mineral sites.

Thirty-eight rock and 11 alluvial samples were taken. The rock samples were of three types; 1) chip - a series of rock fragments taken in a generally continuous line across an outcrop, sometimes from selected parts of outcrops; 2) random chip - a series of rock fragments generally taken from an area of an outcrop; 3) grab - rock pieces or soil taken more or less at random from float (loose rock on the ground), or other loose material. All alluvial samples were grab samples of surficial sand and gravel.

Non-alluvial samples were dried at 190° F. for 48-72 hours; undetermined losses of volatiles, such as mercury, sulfur, and some hydrocarbons may have occurred. Additionally, all the samples were from surface or near surface material and may not directly represent earth materials at minable depths, mainly because of weathering.

The rock samples were crushed, pulverized, mixed and split at WFOC. Rock hammers used in the field and crushing and grinding equipment used in processing samples are made of steel alloy and possibly contribute an undetermined amount of iron and other elements to the samples. Because of this possible iron contamination, splits of seven, crushed, high-silica samples were magnetically screened to remove iron chips and pulped with non-ferrous pulverizers. Splits of rock samples were sent to commercial laboratories for analysis. Forty-eight analyses were performed on most of the rock sample; sulfur was additionally determined for the seven high-silica samples. Elements and compounds and lower detection limits were as follows, by method:

Instrumental neutron activation-- Au (gold), 5 ppb; As (arsenic), 1 ppm; Ba (barium), 100 ppm; Br (bromine), 1 ppm; Ce (cerium), 10 ppm; Co (cobalt), 10 ppm; Cr (chromium), 50 ppm; Cs (cesium), 1 ppm; Eu (europium), 2 ppm; Hf (hafnium), 2 ppm; Ir (iridium), 100 ppb; La (lanthanum), 5 ppm; Lu (lutetium), 0.5 ppm; Mo (molybdenum), 2 ppm; Rb (rubidium), 10 ppm; Sb (antimony), 0.2 ppm; Sc (scandium), 0.5 ppm; Se (selenium), 10 ppm; Sm

(samarium), 0.1 ppm; Sn (tin), 200 ppm; Ta (tantalum), 1 ppm; Tb (terbium), 1 ppm; Te (tellurium), 20 ppm; Th (thorium), 0.5 ppm; U (uranium), 0.5 ppm; W (tungsten), 2 ppm; Yb (ytterbium), 5 ppm; Zr (zirconium), 500 ppm.

Borate fusion and plasma emission spectroscopy -- Al_2O_3 (alumina), 0.01%; CaO (calcium oxide, 0.01%; Fe_2O_3 (ferrous oxide), 0.01%; K_2O (potassium oxide), 0.01%; MgO (magnesium oxide), 0.01%; MnO (manganese oxide), 0.01%; Na_2O (sodium oxide), 0.01%; P_2O_5 (phosphorus pentoxide), 0.01%; SiO_2 (silica), 0.01%; TiO_2 (titanium dioxide), 0.01%. Normalizing this data to 100% may be desired for some uses.

Multi-acid total digestion and plasma emission spectroscopy-- Ag (silver), 0.5 ppm; B (boron), 2 ppm; Cd (cadmium), 1 ppm; Cu (copper), 1 ppm; Li (lithium), 1 ppm; Ni (nickel), 1 ppm; Pb (lead), 5 ppm; Zn (zinc), 1 ppm.

Multi-acid total digestion and atomic absorption-- Be (beryllium), 0.5ppm.

Leco furnace - S (sulfur), 0.01%, only for seven silica-rich samples.

Gravimetry-- LOI (loss on ignition), 0.01 percent.

Six of the rock samples were checked for soluble hydrocarbons by leaching the dried pulp with naphtha and drying the leachate (see Emmons, 1921, p. 28, detection limit about 0.05%).

All alluvial samples were partially concentrated by panning or screening in the field and further concentrated on a laboratory-sized Wilfley 1/ table. Resulting heavy mineral fractions were examined with a binocular microscope and minerals identified. When gold was detected, larger particles were hand-picked and weighed along with fine gold recovered by amalgamation.

Splits and concentrates in the preparation laboratory were checked for radioactivity and fluorescence, and a Geometrics 1/ model GR-101A scintillometer was used for field radiometric readings. No field readings were greater than 100 cps (counts per second), indicating no economic concentrations of radioactive minerals at the surface.

Element concentrations do not necessarily denote economic significance; contents may be so low or so intermixed with other material that mining would not be profitable.

1/ Use of the brand is not intended as an endorsement.

Minability of commodities such as sand and gravel, limestone, dolostone, and silica is dependent upon several factors besides quality and quantity. Markets must exist or, preferably, be expanding. Transporation costs must be minimized. Zoning and political restrictions must be favorable. Many companies using commodities such as silica and limestone own nearby raw-material sources, and these sources are usually sufficient for decades or centuries of production. Many such companies using outside sources have customized their processes to fit their sources and are unwilling to switch providers, even if a new supplier can offer lower costs.

Materials such as sand and gravel, limestone, dolostone, and silica may exist in large quantities at favorable grades but not be minable in the near future. Such materials represent only a stock for which resources may be calculated if marketing, transportation, and other conditions become favorable.

Resource/reserve terminology of the USBM and USGS (1980) is used as a guideline in this report. Technical terminology complies with Bates and Jackson (1980).

ACKNOWLEDGEMENTS

J. Douglas Causey, physical scientist at WFOC, assisted the author during field work. Dan Bartholme, geologist with the BLM in Salmon, ID, provided access maps and information about roads and geology in the study area.

GEOLOGIC SETTING

The Borah Peak study area is on the western flanks of the Lost River Range, a block-fault mountain range within the Basin and Range physiographic province. Rocks (fig. 2) in the study area are predominantly Paleozoic quartzite, shale, phyllite, dolostone and limestone. From oldest to youngest, the strata include (Wilson, 1989; see Ross 1947, 1963, and Nelson and Ross, 1969), the Wilbert Formation Equivalent, an unnamed phyllite, Summerhouse Formation, Kinnickinic Quartzite, Fish Haven Dolomite Equivalent and related undifferentiated formations, Three Forks Formation, and McGowan Creek Formation.

The Wilbert Formation Equivalent, probably lower Cambrian, is a tan to pink quartzite. Overlying the Wilbert Formation equivalent is a gray to red-brown phyllite, probably also Cambrian.

The lower Ordovician Summerhouse Formation is comprised of gray, white, brown, and purple quartzite and considerable dolostone. The middle Ordovician Kinnickinic Quartzite is mostly white quartzite. The Fish Haven Dolostone and undifferentiated formations of upper Ordovician and lower Silurian age have limited extent in the study area.

Small amounts of the Devonian Three Forks Formation (limestone and siltstone) and McGowan Creek Formation (siltstone, shale, and limestone) occur in the northeastern corner of the study area.

Holocene and Pleistocene alluvium, fanglomerates, colluvium, glacial moraines, and landslides occur throughout the study area. Alluvial fans, spreading west from canyons draining the area, are extensive.

High-angle block faulting trends northwest along the active Lost River Fault, and a few high-angle faults strike northeast. These faults join low-angle faulting at depth. Synclinal and anticlinal folding trend north to northwest (Ross, 1947, p. 1135-1139, 1963; Ruppel, 1982).

The Lost River Fault trends northwest along the length of the study area. The fault has a near vertical surface dip and a subsurface dip of about 45° SW. to the zone of origin at about 52,000 ft depth. In 1983, an earthquake of magnitude Ms 7.3 forced dip-slip movement along the Lost River Fault, creating scarps about 16 ft high and throws of some 8-9 ft. (Crone, 1988; see Stein and Bucknam, 1985). Older episodes of movement cumulatively developed a zone or multiple zones of rupture, crushing, folding, and shearing at least 500 ft wide, although movement at any particular time may be confined to a few distinct zones of rupture, as shown by the 1983 scarps. Surficial slumping on steep hillsides and along ridge crests formed satellite scarps and fissures for at least 1 mi on either side of the more deeply-seated Lost River Fault. The earthquake initiated landsliding of water-saturated sand and gravel at Birch Springs, stripping vegetation from tens of acres.

Fault zones such as the Lost River Fault have occasionally been the focus of mineralization. Some fault zones provide a conduit, or, alternately, a barrier, for hydrothermal mineralizing solutions, and some make rock more receptive to mineralization because of crushing and fracturing. Local barite and quartz veins, and limonitic and minor copper-blue staining of weathered rocks along the Lost River Fault Zone may represent mineralization related to solution movement along the zone, or greater chemical reactivity due to crushing.

MINING HISTORY

Earliest mining claims near Borah Peak were located in the early 1880's (Capstick, Mayerle, and Buehler, 1987). In the study area, an old lode mining claim, the Inter-Ocean, was recorded in 1892 and described in Custer County records as being 1 mi north of the Vance Ranch, probably near present-day Vance Canyon (fig.3, table 1, area K). Another, the Golden Rule lode claim, was recorded in 1897 and said to be 2 mi north of the Vance Ranch on Vances Spring Creek, assumed to be Vance Canyon (fig.3, table 1, area K). The Mineral King, Mineral Queen, and Twin Falls claims are described in 1918 county records as having been located 1.25 mi north of the junction of Thousand Spring Creek and Big Lost River. A caved adit at Coyote Springs and a nearby adit with about 40 ft of underground workings (fig. 3, table 1, area M) are of unknown age, but are estimated to be at least 30 years old.

Sand and gravel and crude fill for road construction and maintenance have been mined intermittently at two State of Idaho borrow pits west of the study area (fig. 3, table 1). No sand and gravel borrow pits were found in the study area.

There were no active mining claims in the study area in 1988, nor were there any current oil and gas or geothermal energy leases or applications.

MINERAL COMMODITIES AND APPRAISAL

Mineralized areas, claims, and prospects in and near the study area were evaluated. Sample localities are shown on figure A-1 and analyses reported in appendix tables A-1 to A-4; summaries are described in table 1 and shown on fig. 3.

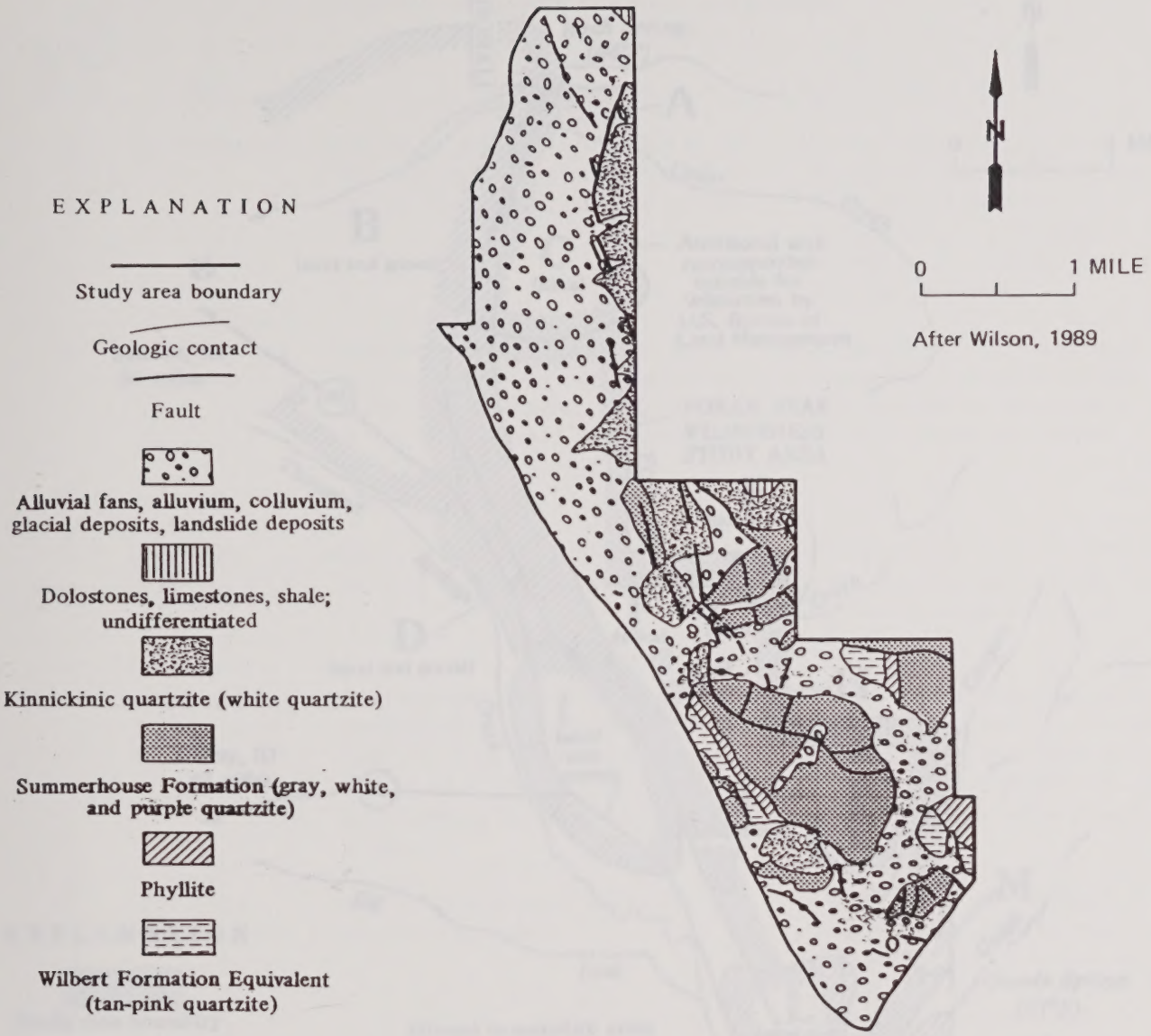

FIGURE 2.– Geologic map of the Borah Peak study area, Custer County, ID

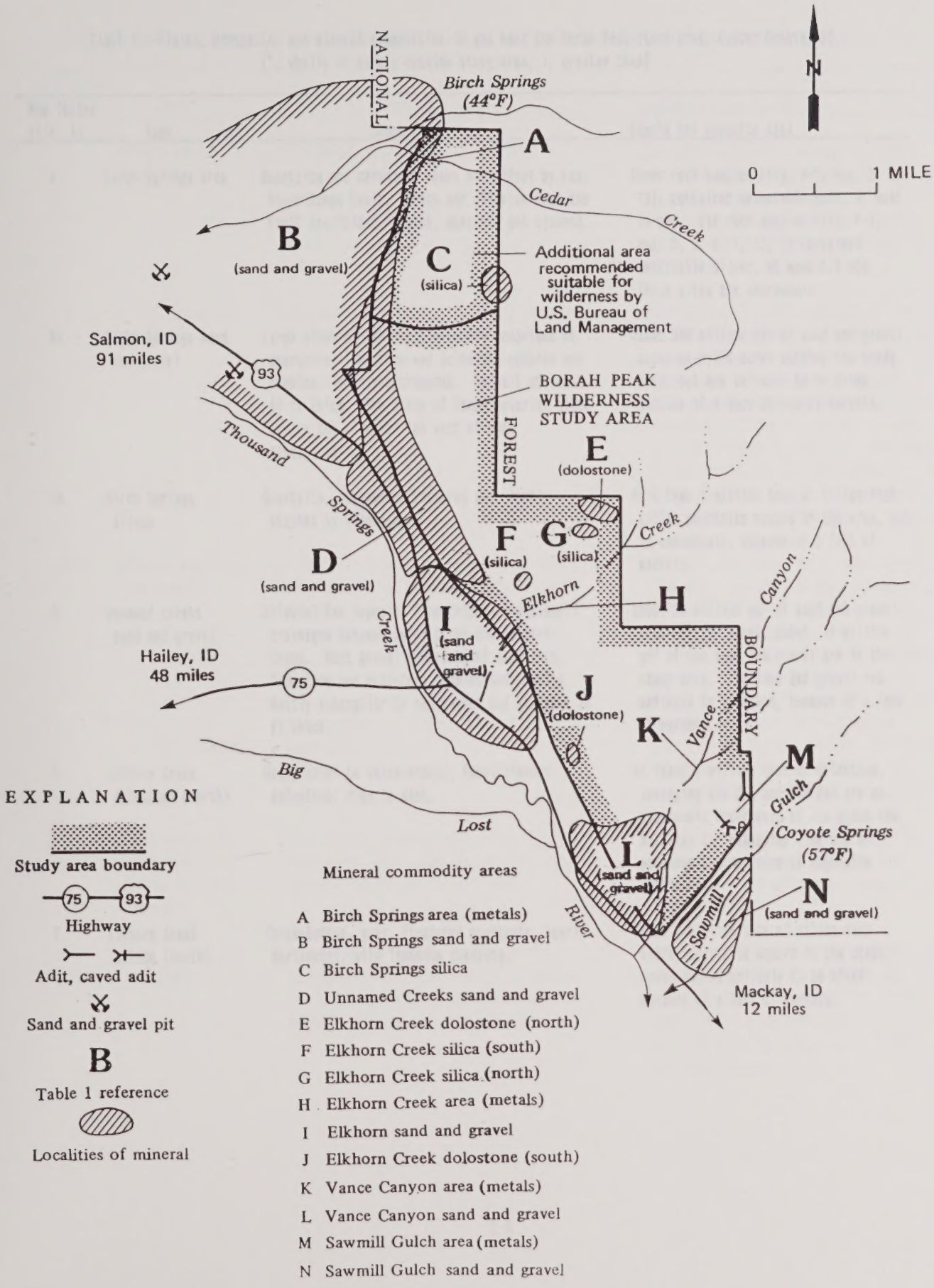

FIGURE 3.– Mines, prospects, and mineral commodities in and near the Borah Peak study area, Custer County, ID

TABLE 1.--Claims, prospects, and mineral commodities in and near the Borah Peak study area, Custer County, ID
[*, wholly or partly outside study area; >, greater than]

Map letter (fig. 3)	Name	Summary	Sample and resource data
A	Birch Springs area	Quartzite and carbonate rocks are offset by Lost River Range Fault. Rocks and alluvium near the fault are folded, broken, sheared, and crushed.	Three rock samples (fig. A-1, nos. 2, 3, 13), contained detectable gold, at most 14 ppb. Six rock samples (fig. A-1, nos. 1, 2, 6, 9, 12, 13 contained detectable silver, at most 2.3 ppm. These sites are uneconomic.
B*	Birch Springs sand and gravel	Large alluvial fan deposit mostly comprised of quartzite, limestone and dolostone cobbles and pebbles. Mostly subrounded. Deposit at least 50 ft thick. Two State of Idaho material sites are in the alluvial fan west of the study area.	About 300 million yd^3 of sand and gravel occur on 3,300 acres outside the study area, but are unlikely to be mined, because of a lack of nearby markets.
C*	Birch Springs silica	Quartzite, intensely fractured and lightly stained by limonite.	More than 1 million tons of silica-rich (>97%) quartzite occurs in the area, but is uneconomic, because of a lack of markets.
D	Unnamed creeks sand and gravel	Alluvial fan deposits from tributary and small drainages between Cedar Creek and Elkhorn Creek. Most gravel comprised of quartzite, limestone and dolostone cobbles and pebbles. Mostly subangular to subrounded and at least 20 ft thick.	About 30 million yd^3 of sand and gravel occur on 830 acres; about 15 million yd^3 of the sand and gravel are in the study area. The sand and gravel are unlikely to be mined, because of a lack of markets.
E	Elkhorn Creek dolostone (north)	Gray, thin- to thick-bedded, fossiliferous dolostone; dips to east.	At least 9 million tons of dolostone, averaging 31% CaO and 20% MgO are an uneconomic occurrence of low-grade raw material for magnesian lime and an uneconomic occurrence of magnesium metal.
F	Elkhorn Creek silica (south)	Thick-bedded, gray, fractured quartzite, nearly horizontal, with limonite staining.	About 2 million tons of silica-rich (>97%) quartzite occurs in the study area, but is unlikely to be mined because of a lack of markets.

TABLE 1.--Claims, prospects, and mineral commodities in and near the Borah Peak study area, Custer County, ID--Continued

Map letter (fig. 3)	Name	Summary	Sample and resource data
G	Elkhorn Creek silica (north)	Thick-bedded gray quartzite; dips east.	About 650,000 tons of silica-rich (>97%) quartzite occurs in a talus. Rock in place contains more than 2 million additional tons of silica-rich material. This silica is unlikely to be mined because of a lack of markets.
H	Elkhorn Creek area	Quartzite and carbonate beds offset by Lost River Range Fault. Minor copper, iron, quartz, and barite minerals at surface in sheared, brecciated rocks.	Four samples (fig. A-1, nos. 25, 27, 30, 31) contained detectable silver, at most 1 ppm. One sample (fig. A-1, no. 24) was mostly barite but volume was only a few hundered pounds. Sample 23 (fig. A-1 contained 31 ppm thorium and 8.7 ppm uranium. Sample 25 (fig. A-1) contained 43 ppm thorium and 7.7 ppm uranium. Sites containing metallic elements are too low-grade to be mined.
I*	Elkhorn Creek sand and gravel	Alluvial fan deposit boulder, pebble, cobble gravel, mostly of quartzite, limestone and dolostone pebbles and cobbles. Mostly subrounded. Deposit at least 50 ft thick.	Sand and gravel occur on 60 acres inside the study area and 580 acres outside. About 50 million yd^3 of sand and gravel occur in the study area. The sand and gravel are unlikely to be mined, because of a lack of nearby markets.
J	Elkhorn Creek dolostone (south)	Orange-weathering, gray, thin- to thick-bedded fossilferous dolostone.	At least 1 million tons of dolostone averaging 20% MgO and 31% CaO occur and are too low-grade to mine for lime and are an occurrence of magnesium metal.
K	Vance Canyon area (Inter-Ocean and Golden Rule Lode claims)	Quartzite and carbonate beds, sheared by Lost River Range Fault. Abundant specular hematite in quartzite and quartz gash veins.	A sample of a quartz vein with about 20% specular hematite (fig. A-1, no. 43) contained 25 ppm molybdenum. This is uneconomic.
L*	Vance Canyon sand and gravel	Alluvial fan deposit mostly of quartzite, limestone and dolostone pebbles and cobbles. Mostly subangular to subrounded. Deposit at least 20 ft thick.	Sand and gravel cover 320 acres inside the study area and 190 acres outside. About 10 million yd^3 of sand and gravel occur in the study area, but are unlikely to be mined because of a lack of nearby markets.

TABLE 1.--Claims, prospects, and mineral commodities in and near the Borah Peak study area, Custer County, ID--Continued

Map letter (fig. 3)	Name	Summary	Sample and resource data
M*	Sawmill Gulch area	Quartzite and carbonate beds sheared by Lost River Range Fault. Quartz lenses and veins in wide zones of gray mylonite. Two short adits; one is caved at portal, and the other has about 40 ft of underground workings.	One sample (fig. A-1, no. 46) contained 1.6 ppm silver. Another rock sample (fig. A-1, no. 47) contained 203 ppm lithium, 23 ppm thorium, and 5.4 ppm uranium. These sites are not economic.
N*	Sawmill Gulch sand and gravel	Alluvial fan deposit, mostly quartzite, limestone and dolostone pebbles and cobbles. Mostly subrounded. Deposit at least 50 ft thick.	About 25 million yd^3 of sand and gravel occur on 320 acres outside the study area. This sand and gravel is unlikely to be mined because of a lack of nearby markets.

Gold, Silver, Copper, Lead, Zinc, Barium and Rare Earth-Related Elements

Small, uneconomic amounts of gold, silver, copper, lead, zinc, barium, and rare earth-related elements occurred in samples from the Borah Peak Study area. Some analyses with maximum analytical concentrations have been selected from table A-2 to demonstrate the low levels of mineralization.

Samples from faulted and sheared slopewash, quartzite, and dolomite in the Birch Springs area (fig. 3, table 1, areas A, C) contained small amounts of gold, at most 14 ppb (fig. A-1 no. 3), content of silver was also low, at most 2.3 ppm (fig. A-1, no. 6). Maximum amounts of copper (207 ppm fig. A-1, no. 11), lead (169 ppm, fig. A-1, no. 12), zinc (153 ppm, fig. A-1, no. 6), antimony (17 ppm, fig. A1, no. 11), thorium (8.6 ppm, fig. A1, no. 6), and uranium (6.3 ppm, fig. A-1, no. 6) were also low.

Samples from the Elkhorn Creek area (fig. 3, table 1, area H) also contained small amounts of silver and copper. Maximum amount of silver was 1 ppm (fig. A-1, no. 27), and of copper 160 ppm (fig. A-1, no. 24). Sample 24 (fig. A-1) was almost entirely barite, but only a few hundred pounds of barite occur at this site. Sample 23 (fig. A-1) contained 2.1 ppm beryllium, 300 ppm cerium, 18 ppm tantalum, 31 ppm thorium, 8.7 ppm uranium, and 880 ppm zirconium. Sample 25 (fig. A-1) contained 4 ppm beryllium, 43 ppm thorium, and 7.7 ppm uranium. Sample 39 (fig. A-1) contained 15 ppm thorium and 3.2 ppm uranium in a small quartz stringer.

A sample of quartz vein (fig. A-1, no. 43) in Vance Canyon (fig. 3, table 1, area K) contained about 20% specular hematite and 25 ppm molybdenum. Neither the iron or molybdenum are economic.

Samples from the Sawmill Gulch area (fig. 3, table 1, area M) contained similarly small amounts of metals. Sample 46 (fig. A-1) contained 1.6 ppm silver. Sample 47 (fig. A-1) contained 62 ppm zinc, 3.1 ppm beryllium, 190 ppm cerium, 203 ppm lithium 23 ppm thorium, and 5.4 ppm uranium. The two short adits, one caved, one with about 40 ft of underground workings, were probably driven along quartz lenses and veins in sheared rock along the Lost River Fault.

The amounts of gold, silver, copper, lead, zinc, barium and rare earth-related elements are too small by factors of about one hundred to be mined. Alluvial samples contained uneconomic gold, less than $0.03 per yd^3 (table A-4), which is too low-grade to be mined.

Carbonates

Most of the carbonates in the study area are in gray, yellow, and white, massive-to-fissile beds of dolostone and minor limestone with low to moderate dips. Beds are hundreds of ft thick and crop out for miles

in and near the study area. Small, white-to-tan carbonate veinlets lace some of the carbonates. Fossil invertebrates, mainly corals, bryozoans, clams, pectens, and crinoids are abundant.

Cement

Amounts of high-calcium carbonate necessary for cement or high-calcium lime manufacture are limited in the Borah Peak study area; most of the carbonates are dolostone and unsuited for cement production. One sample (fig. A-1, no. 35) from the Elkhorn Creek area (fig. 3; table 1, area H) was across a thin bed of limestone and contained 45.1 percent CaO, 8.36 percent Fe_2O_3, 1.54 percent MgO, and 3.07 percent SiO_2. Loss on ignition 2/ was 39.7 percent. This sample was of a thin, faulted and folded limestone bed and no resources were estimated. Quality is poor (see Boynton, 1980, Bowen, 1973) and the occurrence is too small to mine.

Lime

Dolostone from the study area could be used for low-grade lime. Dolostone at two sites (fig. 3, table 1, areas E, J) favorably situated for mining was sampled and tonnages of rock estimated.

A summary of dolostone tonnage estimates (using a specific gravity of 2.8) and analyses is in table 2. Quantity of dolostone is probably adequate but quality is low-grade. Some possible uses (table 2; see Boyton, 1980, Bowen, 1973), are steel flux, refractories, glass-making, and low-grade magnesium lime. Markets are limited and transportation distances great. Therefore, it is unlikely that any of the 10 million tons or more of dolostone in the study area will be mined for lime.

Magnesium (Metal)

The dolostones considered for lime production are similar chemically to rocks mined for magnesium elsewhere (Bennett, 1944, p. 6-7 and supplement), although silica, alumina, and iron oxide contaminants are excessive in the Borah Peak study area. Three percent is the maximum desirable amount of silica, alumina, and iron oxides; average total content of silica, alumina, and total iron (as ferrous iron) from dolomites samples 16, 17, 31, 38, 40 (fig. A-1; fig. 3, table 1, areas E, J) is about 6.1 percent. Locally, dolostone may meet standards, as at the site of sample 16 (fig. A-1). The relatively large amounts of impurities, lack of a nearby market, and competition from established sources suggests classifying the dolomite in the study area as an occurrence of magnesium unlikely to be mined.

2/ Loss in weight which occurs above boiling point (Bates and Jackson, 1980)

Table 2.--Selected dolostone sites in the Borah Peak study area, Custer County, ID

[NA, not applicable; <, less than; >, greater than]

Area (fig. 2)	Name	Dimensions (ft)	Tons (millions)	Samples (fig. A-1)	Raw Analyses (%; Table A-3) Al_2O_3	CaO	Fe_2O_3	MgO	P_2O_5	SiO_2
E	Elkhorn Creek Dolostone (north)	2,000 by 500 by 100	9	16	0.36	32.17	0.22	21.00	0.11	1.43
				17	1.45	29.66	0.47	19.76	0.24	5.93
J	Elkhorn Creek Dolostone (south)	500 by 250 by 100	1	40	0.74	31.46	1.70	19.98	0.13	1.89
	Preferred (Boynton, 1980; Bowen, 1973)			for:						
				Magnesian lime	NA	NA	NA	10-15	NA	NA
				Steel flux	NA	NA	NA	<4	<0.006	<2-5
				Refractories	<1	NA	<1	>18	NA	<1
				Glass making	&	@	<0.02-0.1	@	&	&

@, $CaCO_3$ plus $MgCO_3$, >98%

&, Uniformity is critical as tracking varying content of impurities is difficult or impossible in the glass-making process.

Sand and Gravel

Sand and gravel are widespread in the western part of the study area and vicinity (fig. 3, A-1, fig. 1, A-1). The sand and gravel are mostly Quaternary and Pleistocene alluvial fans containing dolostone, limestone, quartzite, and other metamorphosed sedimentary rocks. The alluvial fans were deposited by streams draining the Lost River Range, east of the study area. The fans are extensive; miles long and wide and tens to hundreds of feet thick.

About 30 million yd^3 of sand and gravel occur in the study area and about 410 million yd^3 are adjacent. Five alluvial fans (fig. 3, areas B, D, I, L, N) summarized in table 3, cover at least nine mi^2. Additional sand and gravel occur nearby. Sand and gravel in the study area are probably similar to road fill and crushed aggregate mined intermittently at two Idaho Department of Transportation material sites about 1 mi west of the north end of the study area (fig. 2, A-1). However, mining the sand and gravel inside the study area is unlikely because of the abundance nearby of equally good or better material closer to existing and foreseeable markets.

Silica

Quartzite in and near the Borah Peak study area contains high percentages of silica. The quartzite is in Paleozoic, massive, gently or moderately dipping, gray, brown, blue, yellow, and purple beds extending for miles.

An estimated 6 million tons of silica-rich quartzite (greater than 97% silica) occurs in the study area at three sites (fig. 3, table 1, areas C, F, G) favorably situated for mining (table 4). Other quartzite, which crops out over about one-third of the study area (fig. 2) occurs nearby; the Kinnickinic Quartzite is probably mostly silica-rich (>97%), but the Summerhouse Formation quartzite contains objectionable aluminum, calcium, and iron.

Quantities and quality of silica-rich quartzite in the study area are probably adequate for metallurgical uses such as ferrosilicon, fluxes, silica brick, and linings (table 4; see Griffiths, 1987; Murphy and Henderson, 1983). A specific gravity of 2.65 was used for quartzite and 130 lb/ft^3 for quartzite talus. The quartzite is unlikely to be mined however, because of a lack of markets.

Geothermal Energy

Major faults such as the Lost River Range Fault can localize geothermal energy, but no surface expressions of such energy were identified. Low-temperature springs in the Borah Peak study area flow at between 44 °F. and 57 °F., too low for most geothermal energy uses.

TABLE 3.--Sand and gravel in alluvial fans in and near the Borah Peak study area, Custer County, ID

[>, greater than]

Map letter (fig. 2)	Name	Thickness (ft)	Acres	Volume (million yd^3)	
				Inside study area	Outside study area
B	Birch Springs	>50	3,300	None	300
D	Unnamed creeks	>20	830	15	30
I	Elkhorn Creek	>50	640	5	45
L	Vance Canyon	>20	510	10	10
N	Sawmill Gulch	>50	320	None	25

Table 4.--Selected silica-rich quartzite sites in the Borah Peak study area, Custer County, ID

[*, outside study area; NA, not applicable; <, less than; >, greater than]

Area (fig. 2)	Name	Dimensions (ft)	Tons (millions)	Samples (fig. A-1)	Raw Analyses (%; Table A-3) Al_2O_3	CaO	Fe_2O_3	MgO	P_2O_5	SiO_2	TiO_2
B	Birch Springs Silica	1,000 by 200 by 100	1	9	0.13	0.05	<0.01	0.05	0.10	98.59	<0.01
				10	0.12	0.21	0.13	0.09	0.04	97.82	<0.01
				12	0.14	0.04	0.36	0.08	0.01	97.80	<0.01
				13*	0.35	0.44	0.16	0.14	0.17	97.49	<0.01
F	Elkhorn Creek Silica (South)	500 ft by 500 ft by 100 ft	2	21	0.22	0.06	0.03	0.07	0.05	98.04	<0.01
G	Elkhorn Creek Silica (north)	1,000 by 500 by 100 (talus) plus	0.65	18	0.27	0.07	<0.01	0.10	0.08	97.96	<0.01
				19	0.19	0.05	0.03	0.05	0.15	98.34	<0.01
		1,000 by 250 by 100 (out-crop)	2	None							
	Preferred (Griffiths, 1987) for:										
				Ferrosilicon	<0.4	<0.2	<0.2	<0.2	<0.1	>98	<0.002
				Fluxes	<1.5	NA	<1.5	NA	Nil	>90	NA
				Linings	NA	NA	NA	NA	NA	>96	NA
				Silica brick	<0.5-1	@	<2.5	@	NA	>97	<0.2

@ Total alkalais <0.2%

Coyote springs (fig. 2, area M) may be warm enough, at 57 °F. for a source of heat for a small domestic heat pump (Dean Howell, Kool-Fire West, Spokane, WA, oral communication 1988), but markets are not foreseeable.

Oil and Gas

There are no indications of oil and gas at the surface in the Borah Peak study area. None of six samples (fig. A-1, nos. 1, 2, 8, 24, 47, 48) from high angle structures and other sites likely to serve as conduits for hydrocarbons from rocks at depth contained detectable hydrocarbons (detection limit about 0.05 percent). Sandberg (1983, p. F4) classified potential for oil and gas in this region as low to zero. Sedimentary rocks at the surface in this region have been heated to high enough temperatures that most liquid hydrocarbons may have been broken down to gases, although rich source rocks may exist or may have existed here and some liquid hydrocarbons could have survived locally. (Sandberg, 1983, p. F4). Gases released by thermal degradation may have been trapped in structurally or stratigraphically favorable sites. However, no evidence of oil and gas was found in the study area during this work that refutes the conclusions of Sandberg.

RECOMMENDATIONS

No additional work is recommended. If markets and other conditions favoring mining of sand and gravel, limestone, dolostone, magnesium, and silica from the study area develop, additional sampling and use-specific testing of these commodities would be necessary.

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APPENDIX

Page

Figure A-1. Mines, prospects, and sample localities in and near the Borah Peak study area, Custer County, ID 27

TABLES

Table A-1. Description of rock samples from the Borah Peak study area and vicinity, Custer County, ID 28

A-2. Thirty-seven-element analysis of rock samples from the Borah Peak study area and vicinity, Custer County, ID 31

A-3. Whole-rock analysis of samples from the Borah Peak study area and vicinity, Custer County, ID 35

A-4. Alluvial samples from the Borah Peak study area and vicinity, Custer County, ID 36

TABLE A-1.--Description of rock samples from the Borah Peak study area and vicinity, Custer County, ID

[*, outside study area; NA, not applicable]

No. (fig.A-1)	Type	Length (ft)	Description
1	Grab	NA	Gray, lightly cemented carbonate chips (colluvium) along Holocene fault scarp.
2	do	NA	Gray, fractured carbonate boulder in glacial till along Holocene fault scarp.
3	do	NA	Gray, limonite-stained carbonate and quartzite at Holocene fault scarp. Possibly in glacial till.
6	Chip	7.6	Yellow-, brown-, and black-stained argillic consolidated alluvial fan deposit along Holocene fault scarp.
7	do	14.0	Gray carbonate, sheared and brecciated with yellow-orange stains. Strikes N. 5° E. and dips 85° SE.
8	Grab	NA	Gray, intensely pulverized colluvium along Holocene fault scarp.
9	Random chip	NA	Gray, blocky quartzite.
10	do	NA	Gray, intensely fractured, sheared quartzite. Shearing trends N. 10° W., near vertical dip.
11	Grab	NA	Gray quartzite float with limonite staining.
12	do	NA	Gray quartzite breccia with limonite staining.
13*	Random chip	NA	Gray to white quartzite(?), slightly calcareous, fractured, with minor limonite staining.
16	Grab	NA	Gray carbonate, mostly fine-grained, with horn coral fossils and small, white veinlets.
17	do	NA	Pale gray to tan weathering of gray carbonate with small, lacey white to tan veinlets.
18	do	NA	Selected, rusty-weathered quartzite in talus.

TABLE A-1.--Description of rock samples from the Borah Peak study area and vicinity, Custer County, ID--Continued

No. (fig.A-1)	Type	Length (ft)	Description
19	Grab	NA	Pale gray, massive, blocky quartzite in talus.
20	Chip	1.5	Sample of orange quartzite from orange and white carbonate and quartzite beds. Strike N. 10° W. and dip 60° SW.
21	Grab	NA	Gray to white, massive, fine-grained quartzite with minor limonite staining.
22	do	NA	Selected orange, brecciated, limonitic carbonate and quartzite.
23	do	NA	Brown, coarse-grained talus. Radioactiviy 60-80 cps.
24	Chip	1.1	Intensely sheared quartzite and carbonates and inclusions of coarse-grained green rock with zones of breccia cemented by barite and carbonates, some faintly stained by copper carbonates and limonite.
25	do	0.3	White, yellow, orange, and massive limonite with quartz veinlets and a cap of green gouge. Host rock is gneiss and schist with shearing parallel to foliation. N. 20° E. strike and 42° SE. dip. radioactivity 75 cps.
26	Random Chip	NA	Tan quartzite with small limonite specks. Strike of bedding N. 60° W. and dip 10° SW.
27	Grab	NA	White quartz and red-brown ankerite or siderite in dark-gray dolomite, partly limonite stained.
30	Chip	6.5	Limonitic, intensely sheared, fractured, quartzite.
31	Random chip	NA	Gray, brecciated dolomite with white quartz cement at contact with white quartzite. Local minor limonite.
32	Chip	11.9	Limonitic, intensely sheared, fractured, quartzite.

TABLE A-1.--Description of rock samples from the Borah Peak study area and vicinity, Custer County, ID--Continued

No. (fig.A-1)	Type	Length (ft)	Description
34	Chip	0.25	Gray-green breccia cemented by fine carbonate. Zone strikes N. 55° W. and dips 85° SW.
35	do	1.7	Limonitic carbonate.
37	Random chip	NA	White, pink-tinged quartzite with limonite and manganese-oxide staining.
38	do	NA	Gray, massive dolomite with tan streaks.
39	Chip	3.3	Orange-weathered, sheared, brecciated carbonate. Shearing strikes N. 30° W. and dips 60° NE.
40	do	10.0	Gray, massive carbonate with white veinlets.
41	do	0.25	Quartz vein with minor limonite in carbonate. Narrow, lenticular vein about 10 ft long strikes N. 45° W. and dips 85° NE.
43	Grab	NA	Quartz vein in purple quartzite. Contains 5-20% specular hematite and quartz crystals.
45	Random chip	NA	White to gray, coarse-grained, hard, blocky quartzite with minor limonite stains.
46	Grab	NA	Limonite-stained quartz boxwork float in zone of mylonitic argillite.
47	Chip	6.0	Gray, sheared, quartzose mylonite.
48	Grab	NA	Limonite-stained quartz boxwork from float and dump near caved portal, which trends N. 60° W.

TABLE A-2.--Thirty-seven element analysis of rock samples from the Borah Peak study area and vicinity, Custer County, ID

[*, outside study area; <, less than; >, greater than]

No. (fig. A-1)	Au (ppb)	Ag (ppm)	As (ppm)	B (ppm)	Ba (ppm)	Be (ppm)	Br (ppm)	Cd (ppm)	Ce (ppm)
1	<5	0.7	6	19	460	0.7	6	1	15
2	9	0.7	4	15	480	1.0	<1	<1	<10
3	14	<0.5	5	32	<100	1.1	4	<1	48
6	<5	2.3	28	46	1600	1.8	10	<1	74
7	<5	<0.5	3	19	<100	<0.5	<1	<1	13
8	<5	<0.5	3	14	<100	<0.5	1	2	<10
9	<5	0.6	2	13	<100	<0.5	<1	<1	<10
10	<5	<0.5	2	14	<100	<0.5	<1	<1	<10
11	<5	<0.5	16	30	<100	0.7	<1	<1	23
12	<5	1.0	9	17	<100	<0.5	<1	<1	<10
13*	6	1.3	3	13	<100	<0.5	<1	<1	10
16	<5	<0.5	2	21	<100	0.5	3	<1	<10
17	<5	<0.5	3	16	<100	1.4	2	3	21
18	<5	<0.5	2	13	<100	<0.5	<1	<1	12
19	<5	<0.5	1	14	<100	<0.5	<1	<1	<10
20	<5	<0.5	5	21	<100	<0.5	<1	1	<10
21	<5	<0.5	1	12	<100	<0.5	<1	<1	<10
22	<5	<0.5	3	26	410	<0.5	<1	<1	17
23	<5	<0.5	15	25	6700	2.1	2	<1	300
24	<5	<0.5	19	33	>30000	0.6	<1	3	<23
25	<5	0.8	25	144	820	4.0	<1	<1	82
26	<5	<0.5	4	16	410	0.9	<1	<1	56
27	<5	1.0	<1	64	<100	<0.5	<1	2	11
30	<5	0.8	4	16	1000	<0.5	<1	<1	17
31	<5	0.5	2	18	<100	1.0	3	2	13
32	<5	<0.5	2	15	820	<0.5	<1	<1	16
34	<5	<0.5	4	16	100	<0.5	3	<1	<10
35	<5	<0.5	37	75	450	1.0	4	2	<10
37	<5	<0.5	1	13	<100	<0.5	<1	<1	21
38	<5	<0.5	2	16	<100	1.3	6	3	<10
39	<5	<0.5	4	30	750	0.9	<1	2	110
40	<5	<0.5	4	24	<100	0.8	6	1	<10
41	<5	0.9	1	25	<100	0.8	3	4	12
43	<5	<0.5	<1	36	<100	<0.5	1	<1	<10
45	<5	<0.5	4	13	130	<0.5	<1	<1	21
46	<5	1.6	4	113	290	1.2	2	<1	<10
47	<5	<0.5	22	63	620	3.1	6	<1	190
48	<5	<0.5	4	26	470	0.5	<1	<1	<10

TABLE A-2.--Thirty-seven-element analysis of rock samples from the Borah Peak study area and vicinity, Custer County, ID--Continued

No. (fig. A-1)	Co (ppm)	Cr (ppm)	Cs (ppm)	Cu (ppm)	Eu (ppm)	Hf (ppm)	Ir (ppb)	La (ppm)	Li (ppm)
1	<10	59	2	11	<2	<2	<100	13	20
2	<10	<50	<1	7	<2	<2	<100	9	6
3	<10	100	<1	11	<2	3	<100	18	21
6	<10	290	6	66	<2	2	<100	48	26
7	<10	140	<1	6	<2	<2	<100	5	5
8	<10	<50	<1	7	<2	<2	<100	<5	4
9	<10	280	<1	8	<2	<2	<100	<5	2
10	<10	240	<1	5	<2	<2	<100	<5	<1
11	79	200	<1	207	<2	<2	<100	8	2
12	<10	240	<1	12	<2	<2	<100	<5	<1
13*	<10	190	<1	8	<2	<2	<100	<5	<1
16	<10	<50	<1	18	<2	<2	<100	<5	6
17	<10	<50	<1	4	<2	<2	<100	9	6
18	<10	200	<1	5	<2	<2	<100	<5	<1
19	<10	200	<1	7	<2	<2	<100	<5	<1
20	<10	150	<1	9	<2	<2	<100	<5	3
21	<10	230	<1	5	<2	<2	<100	<5	<1
22	<10	210	<1	9	<2	<2	<100	6	2
23	<10	62	3	42	<2	30	<100	140	11
24	<10	<110	<1	160	<2	<4	<100	8	7
25	79	240	4	67	3	3	<100	37	30
26	<10	280	1	9	<2	9	<100	22	4
27	<10	120	<1	5	<2	<2	<100	<5	4
30	<10	250	<1	13	<2	4	<100	6	2
31	<10	<50	<1	4	<2	<2	<100	<5	7
32	<10	300	<1	9	<2	5	<100	6	7
34	<10	51	<1	12	<2	2	<100	<5	4
35	<10	<50	<1	20	<2	<2	<100	<5	6
37	<10	260	<1	5	<2	3	<100	8	2
38	<10	<50	<1	7	<2	<2	<100	<5	11
39	<10	160	1	12	<2	14	<100	36	6
40	<10	<50	<1	9	<2	<2	<100	<5	10
41	<10	<50	<1	5	<2	<2	<100	<5	4
43	<10	350	<1	4	<2	<2	<100	<5	<1
45	<10	310	<1	9	<2	<2	<100	7	10
46	17	280	<1	7	<2	<2	<100	<5	53
47	40	240	6	26	2	5	<100	91	203
48	<10	300	<1	10	<2	<2	<100	<5	10

TABLE A-2.--Thirty-seven-element analysis of rock samples from the Borah Peak study area and vicinity, Custer County, ID--Continued

No. (fig. A-1)	Lu (ppm)	Mo (ppm)	Ni (ppm)	Pb (ppm)	Rb (ppm)	Sb (ppm)	Sc (ppm)	Se (ppm)	Sn (ppm)
1	<0.5	3	31	17	14	1.3	2.6	<10	1.9
2	<0.5	<2	12	15	<10	0.9	1.2	<10	1.0
3	<0.5	6	66	36	27	1.9	4.3	<10	4.4
6	<0.5	5	433	13	89	2.7	12.0	11	7.3
7	<0.5	9	2	20	<10	0.6	1.4	<10	1.0
8	<0.5	<2	<1	25	<10	1.5	<0.5	<10	<0.5
9	<0.5	19	5	22	<10	0.5	<0.5	<10	<0.5
10	<0.5	17	4	15	<10	0.6	<0.5	<10	<0.5
11	<0.5	13	58	69	11	17.0	0.7	<10	1.8
12	<0.5	19	20	169	<10	2.2	<0.5	<10	<0.5
13*	<0.5	14	4	35	<10	1.4	<0.5	<10	0.5
16	<0.5	<2	469	25	<10	0.4	<0.5	<10	<0.5
17	<0.5	<2	1	15	<10	0.5	2.1	<10	1.2
18	<0.5	14	3	19	<10	0.6	<0.5	<10	0.7
19	<0.5	17	2	9	<10	0.6	<0.5	<10	<0.5
20	<0.5	14	8	8	<10	0.6	1.0	<10	0.9
21	<0.5	16	<1	7	<10	0.4	<0.5	<10	<0.5
22	<0.5	20	14	8	<10	0.4	0.7	<10	1.3
23	<0.5	6	16	17	83	1.6	7.1	<10	19.0
24	<0.5	<12	5	6	<10	3.6	0.7	<10	1.3
25	<0.5	8	100	13	81	1.2	40.0	<10	11.0
26	<0.5	16	15	14	42	0.5	5.0	<10	3.4
27	<0.5	7	9	31	<10	<0.2	3.3	<10	3.9
30	<0.5	18	9	19	<10	1.0	0.8	<10	0.8
31	<0.5	<2	<1	11	<10	0.3	1.1	<10	0.8
32	<0.5	20	4	6	<10	0.6	0.7	<10	0.9
34	<0.5	4	5	9	<10	1.4	1.1	<10	0.7
35	<0.5	3	17	11	<10	2.2	1.2	<10	0.9
37	<0.5	19	6	8	<10	0.5	<0.5	<10	1.3
38	<0.5	<2	<1	13	<10	1.8	1.1	<10	0.7
39	<0.5	8	8	29	61	0.4	5.3	<10	6.1
40	<0.5	<2	8	17	<10	0.3	0.9	<10	<0.5
41	<0.5	2	4	14	<10	0.2	1.3	<10	1.0
43	<0.5	25	3	13	<10	0.3	<0.5	<10	<0.5
45	<0.5	24	4	19	<10	0.4	0.6	<10	0.9
46	<0.5	19	18	13	<10	0.3	9.4	<10	<0.5
47	<0.5	4	56	19	160	0.8	21.0	<10	14.0
48	<0.5	18	12	17	10	0.4	2.2	<10	1.1

TABLE A-2.--Thirty-seven-element analysis of rock samples from the Borah Peak study area and vicinity, Custer County, ID--Continued

No. (fig. A-1)	Sn (ppm)	Ta (ppm)	Tb (ppm)	Te (ppm)	Th (ppm)	U (ppm)	W (ppm)	Yb (ppm)	Zn (ppm)	Zr (ppm)
1	<200	<1	<1	<20	2.1	2.3	<2	<5	54	<500
2	<200	<1	<1	<20	0.7	1.2	<2	<5	26	<500
3	<200	<1	<1	<20	4.5	2.3	<2	<5	16	<500
6	<200	<1	<1	<20	8.6	6.3	<2	<5	153	<500
7	<200	<1	<1	<20	1.5	<0.5	<2	<5	8	<500
8	<200	<1	<1	<20	<0.5	<0.5	<2	<5	13	<500
9	<200	<1	<1	<20	<0.5	<0.5	<2	<5	12	<500
10	<200	<1	<1	<20	<0.5	<0.5	<2	<5	6	<500
11	<200	<1	<1	<20	1.4	0.6	<2	<5	110	<500
12	<200	<1	<1	<20	<0.5	<0.5	<2	<5	19	<500
13*	<200	<1	<1	<20	0.9	<0.5	<2	<5	6	<500
16	<200	<1	<1	<20	<0.5	<0.5	<2	<5	7	<500
17	<200	<1	<1	<20	1.5	0.7	<2	<5	6	<500
18	<200	<1	<1	<20	0.7	<0.5	<2	<5	5	<500
19	<200	<1	<1	<20	<0.5	<0.5	<2	<5	4	<500
20	<200	<1	<1	<20	0.9	<0.5	<2	<5	5	<500
21	<200	<1	<1	<20	0.5	<0.5	<2	<5	4	<500
22	<200	<1	<1	<20	1.4	0.6	<2	<5	13	<500
23	<200	18	3	<20	31.0	8.7	3	6	10	880
24	<200	<1	<1	<20	2.0	<0.5	<2	<5	6	<500
25	<200	<1	2	<20	43.0	7.7	<2	<5	32	<500
26	<200	<1	<1	<20	10.0	2.2	<2	<5	6	<500
27	<200	<1	<1	<20	0.7	<0.5	<2	<5	19	<500
30	<200	<1	<1	<20	1.4	<0.5	<2	<5	8	<500
31	<200	<1	<1	<20	0.8	0.7	<2	<5	4	<500
32	<200	<1	<1	<20	1.3	<0.5	<2	<5	4	<500
34	<200	<1	<1	<20	1.0	0.9	<2	<5	13	<500
35	<200	<1	<1	<20	1.0	5.2	<2	<5	13	<500
37	<200	<1	<1	<20	2.8	0.6	<2	<5	5	<500
38	<200	<1	<1	<20	1.0	0.8	<2	<5	4	<500
39	<200	<1	<1	<20	15.0	3.2	<2	<5	12	<500
40	<200	<1	<1	<20	0.7	0.8	<2	<5	7	<500
41	<200	<1	<1	<20	0.7	<0.5	<2	<5	6	<500
43	<200	<1	<1	<20	<0.5	<0.5	<2	<5	3	<500
45	<200	<1	<1	<20	2.3	0.8	<2	<5	5	<500
46	<200	<1	<1	<20	0.6	2.5	<2	<5	36	<500
47	<200	2	2	<20	23.0	5.4	3	<5	62	<500
48	<200	<1	<1	<20	1.5	1.0	<2	<5	10	<500

TABLE A-3.--Whole rock analysis of samples from the Borah Peak study area and vicinity, Custer County, ID

[*, outside study area; <, less than; to normalize, usea factor= 100/total %]

No. (fig. A-1)	Al_2O_3 (%)	CaO (%)	Fe_2O_3 (%)	K_2O (%)	MgO (%)	MnO (%)	Na_2O (%)	P_2O_5 (%)	SiO_2 (%)	TiO_2 (%)	LOI (%)	Totals (%)
1	2.27	28.64	0.80	0.58	2.12	0.01	0.11	0.20	42.68	0.13	23.60	101.14
2	0.77	36.22	0.30	0.24	0.80	<0.01	<0.01	0.22	29.61	0.04	30.50	98.70
3	3.55	18.69	1.89	1.19	12.48	0.04	<0.01	0.13	37.58	0.19	26.70	102.44
6	9.39	0.96	3.26	2.44	2.21	<0.01	0.07	0.51	72.65	0.44	6.10	98.03
7	1.08	6.56	0.53	0.47	4.39	0.02	<0.01	0.17	73.74	0.06	10.60	97.62
8	0.16	29.23	0.20	0.08	19.10	0.02	<0.01	0.14	10.62	<0.01	41.60	101.15
9‡	0.13	0.05	<0.01	0.08	0.05	<0.01	<0.01	0.10	98.59	<0.01	0.24	99.23
10‡	0.12	0.21	0.13	0.07	0.09	<0.01	<0.01	0.04	97.82	<0.01	0.52	99.01
11	1.13	3.93	1.90	0.36	0.22	0.01	<0.01	0.18	88.57	0.05	3.80	100.15
12‡	0.14	0.04	0.36	0.08	0.08	<0.01	<0.01	0.01	97.80	<0.01	0.36	98.87
13*‡	0.35	0.44	0.16	0.13	0.14	<0.01	0.02	0.07	97.49	0.01	0.37	99.18
16	0.36	32.17	0.22	0.14	21.00	0.02	<0.01	0.11	1.43	0.02	46.10	101.57
17	1.45	29.66	0.47	0.60	19.67	0.03	<0.01	0.24	5.93	0.08	43.20	101.33
18‡	0.27	0.07	<0.01	0.17	0.10	<0.01	<0.01	0.08	97.96	<0.01	0.25	98.90
19‡	0.19	0.05	0.03	0.10	0.05	<0.01	<0.01	0.15	98.34	<0.01	0.25	99.17
20	0.49	5.93	1.19	0.38	3.96	0.04	<0.01	0.16	78.26	0.02	9.50	99.93
21‡	0.22	0.06	0.03	0.13	0.07	<0.01	<0.01	0.05	98.04	<0.01	0.24	98.85
22	0.63	3.58	1.31	0.32	0.79	0.03	<0.01	0.13	86.68	0.05	4.10	97.62
23	13.10	2.22	1.91	6.48	0.87	0.09	0.34	0.17	67.77	0.43	4.20	97.58
24	0.75	14.63	2.40	0.43	8.28	0.27	<0.01	0.17	4.98	0.02	20.80	52.73
25	10.99	0.20	16.45	3.34	1.08	0.22	1.00	0.68	56.55	0.39	7.30	98.20
26	6.79	0.24	1.11	1.91	0.24	0.02	0.08	0.13	87.15	0.37	1.20	99.24
27	0.28	21.93	6.42	0.28	10.80	0.24	<0.01	0.10	30.43	0.01	30.80	101.29
30	0.70	1.54	0.60	0.28	0.45	<0.01	<0.01	0.13	91.91	0.07	2.00	97.68
31	0.73	32.74	0.91	0.35	17.58	0.05	<0.01	0.10	5.95	0.04	43.70	102.15
32	0.80	2.73	0.35	0.31	0.19	<0.01	<0.01	0.14	90.86	0.07	3.00	98.45
34	0.64	29.26	0.88	0.27	9.99	0.04	<0.01	0.08	26.57	0.03	33.10	100.86
35	0.60	45.10	8.36	0.29	1.54	0.33	0.19	0.13	3.07	0.02	39.70	99.33
37	0.45	0.02	0.24	0.24	0.02	<0.01	<0.01	0.19	96.85	0.05	0.10	98.16
38	1.07	29.45	0.63	0.74	19.19	0.03	<0.01	0.15	6.93	0.05	43.20	101.44
39	7.47	3.19	2.46	3.18	1.54	0.05	0.17	0.47	76.09	0.46	5.10	100.18
40	0.74	31.46	1.70	0.53	19.98	0.08	<0.01	0.13	1.89	0.03	45.50	102.04
41	0.44	28.71	2.05	0.06	17.99	0.09	<0.01	<0.03	11.89	0.02	41.00	102.25
43	0.09	0.06	3.67	0.14	0.04	<0.01	<0.01	0.13	98.22	0.04	0.10	102.49
45	2.52	0.17	0.58	0.79	0.14	0.01	0.04	0.16	95.67	0.04	1.20	101.32
46	1.25	0.14	13.38	0.33	0.35	0.63	0.02	0.21	81.67	0.03	2.60	100.61
47	24.35	0.39	8.66	4.80	2.14	0.12	0.52	0.43	52.89	0.76	5.60	100.66
48	1.19	6.18	1.90	0.42	0.70	0.14	0.02	0.17	82.49	0.04	5.70	98.95

‡ Splits magnetically scalped and pulverized with ceramic equipment; samples contained 0.02% or less sulfur.

TABLE A-4.--Alluvial samples from the Borah Peak study area and vicinity, Custer County, ID
[*, outside study area]

No. (Fig. A-1)	Size (ft^3) 1	Description	Gold (oz/yd^3) 1/	Value ($/$yd^3$) 1/
4	0.2	Cobbly active stream gravel.	0	0
5	0.1	Silty sand and gravel, mainly carbonate and quartzite from dry stean bed.	0	0
14	0.1	Silty sand and gravel, mainly angular quartzite to one ft diameter from dry stream bed.	0	0
15	0.1	Gray quartzite boulders and fragments in dry stream channel in alluvial fan. One flat, bright gold flake smaller than 1 mm.	0.00005	0.02
28	0.2	Gravel in active stream channel with pebbles, cobbles, and boulders. Estimated less than 30% smaller than pebbles. Mostly quartzite and carbonates.	0	0
29	0.2	Silt, sand and gravel with cobbles, pebbles, and boulders along active stream channel. Mostly rounded quartzite and minor carbonate. One very angular, bright gold flake smaller than 1 mm.	0.00003	0.01
33	0.1	White, angular quartzite fragments in dry stream channel; minor limonite-cemented quartz fragments.	0	0
36	0.2	Silt, sand, and dry stream gravel with pebbles and and cobbles angular to subrounded.	0	0
42*	0.1	White, purple, and gray quartzite and minor gray dolomite gravel in dry stream bed.	0	0
44	0.1	Rounded quartzite gravel with pebbles, cobbles, and boulders from active stream bed. Possible gold flake smaller than 1 mm.	0.00001	0
49	0.1	Silt, sand, and gravel with boulders, pebbles, and cobbles of rounded quartzite and carbonate from dry stream bed. Angular, bright gold is smaller than 1 mm.	0.00007	0.03

1/ Assumes that gravel expands 25% upon excavation, that gold is pure, and price of gold is $400 per troy ounce.

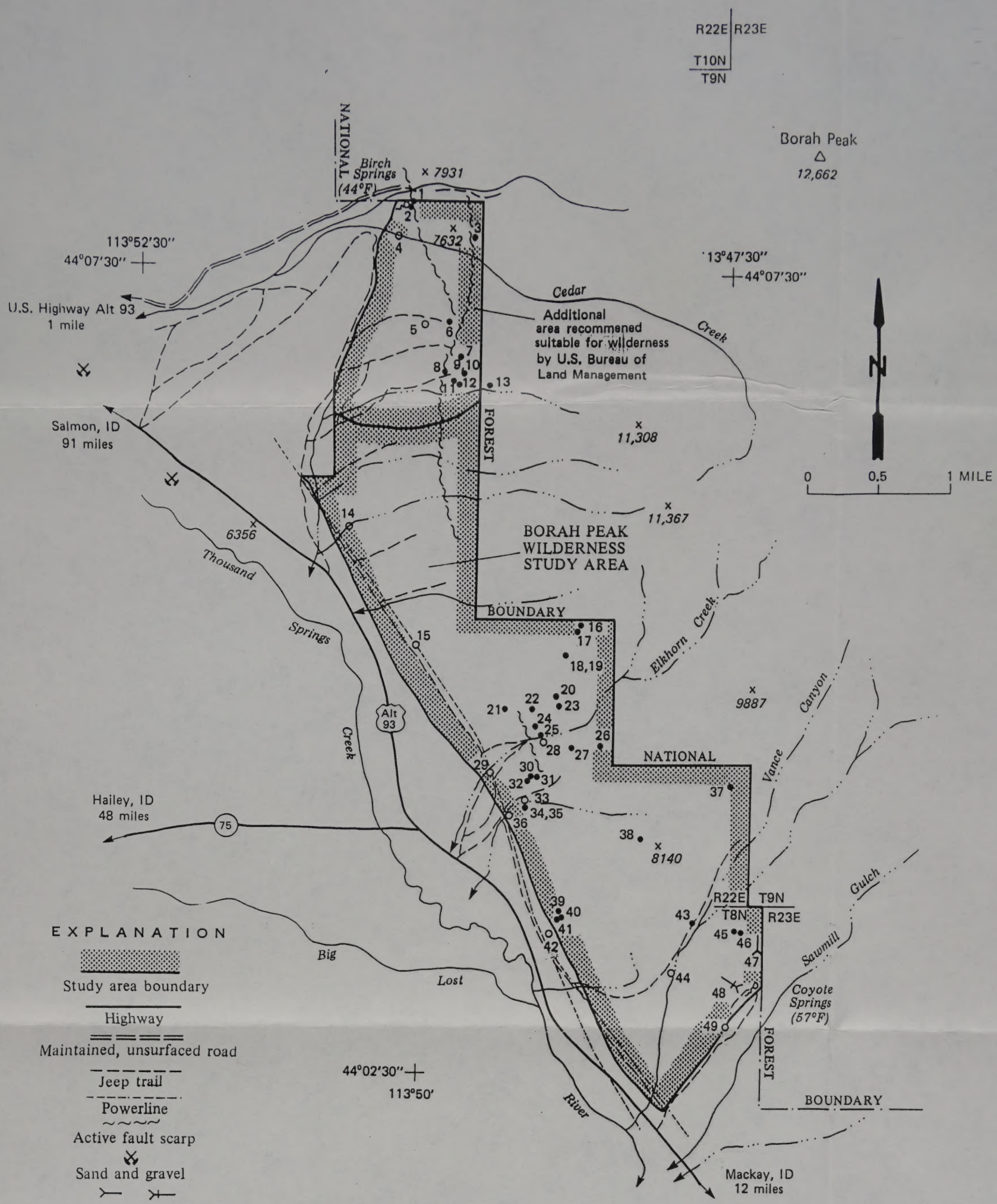

FIGURE A-1.– Mines, prospects, and sample localities in and near the Borah Peak study area, Custer County, ID